THE CONCEPT FOR CONSTRUCTION OF COLORIMETRIC SENSORS FOR BIOMEDICAL RESEARCH

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Optical measurements stay a main analytic technics. They are used to control chemical composition, physical properties definition, supervision of technology processes in many areas as laboratory analyses, ecological monitoring, pharmaceuticals, field-test analyses and other [1-4].

In proposed colorimeter we realized a color coordinates measurement method for a diffusion reflective light. Main idea of its design is a minimal cost with saving a most metrological characteristics and functionality. A block diagram of the colorimeter is represented on fig. 1. We use several technical conceptions to build it.

At first, color sensor is used as an optical detector. Several companies represent them on the market, Hamamatsu and Avago companies are leaders in construction of such optical transducers. The developed colorimeter is based on S9037 from Hamamatsu that has matrix of optical converters which have optical filters on ranges for red, green and blue spectral fields with spectral area of sensitivity 400÷720 nm (conventional range of visible light). Besides the color sensor includes pre-amplifiers for three channels, 12-bit ADC, buffers and sensor control module which supervises a measurement process and a digital serial interface so it is a complete list for a signal processing. Important feature of the sensor is big sensitive area 0.32 mm^2 for each channel. Last one does this sensor especially convenient to analytical instrumentation and measuring systems. Low power consumption, 12 bit per each color channel signal resolution, and probability to adjust sensor sensitivity does this sensor a dominant device for color measurement.

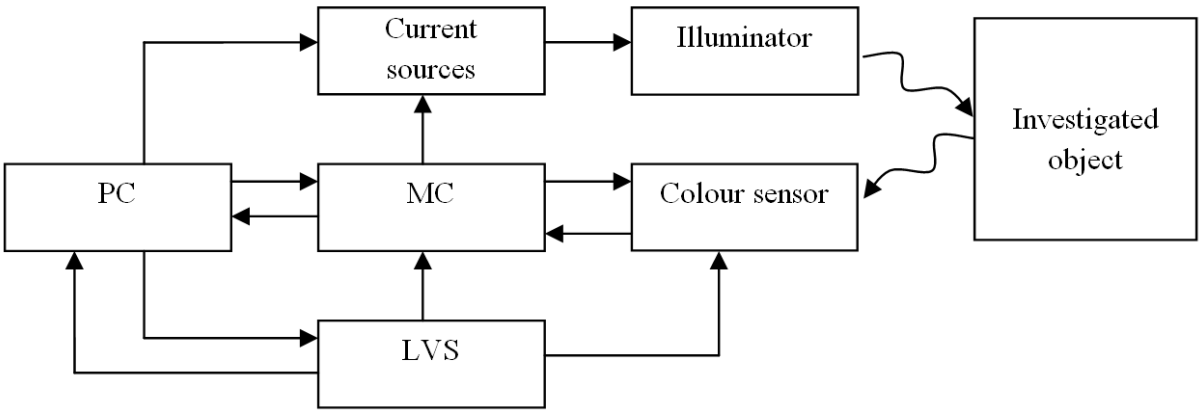

Fig. 1. Block diagram of the colorimeter: PC – personal computer, MC – microcontroller, LVS – line voltage stabilizer

At second, for lighting is used a light source with long life time, good stability, and shot start-up time. This source is white super luminescent light emitting diode (LED). LED is a high efficient illuminant that is significant for portable devices, perfect life time and negligible small start-up time is sufficient also.

Spectral characteristics of sources are important because composition of reflected light (color) from object depend on a spectral characteristic of illuminant (blue object in red light would be black). So for color measurements is need ideal white illuminant. A real illuminant is not really linear so colorimeter optical transducers should have different sensitivity for color channels. Undoubtedly scaling of sensitivity of transducers is not precisely correct reproduce standard light. To solve this problem additional mathematical operation is used. However in many applications is not important absolute value calibration procedure and reference measurement is used according to obtained calibration curve or calibration by ideal white surface. Frequently as ideal white object it is use magnesium oxide or barium sulphate pressed powders, tetrafluorethylene (teflone® or spectrolone®), spatial «milk» glasses etc. In some situations as etalon use white paper but it must do not have luminescent bleach powdering that is in many office «white» paper.

In our colorimeter color sensor with spectral sensitivity rough to human eye is that is etalon spectral sensitivity in color measurements. Four pure white LED from OptoSupply OSW5DA5201A is used as illuminant, small irradiation angle (for 50% power level it is 8 spherical deg.), high illumination (50000 mcd at 20 mA forward current), chromaticity coordinates (x = 0.27; y = 0.28 in XY-coordinates system) near to illuminant type C and low cost defined selection. Sensitivity of each channel is determined by colorimeter calibration with ideal white object in the colorimeter. To white balance procedure we use tetrafluorethylene 10 mm height cylinder stamped in black plastic holder.

The specific feature of the colorimeter is using of four LEDs for illumination that is placed around sensor and directed at 45° to an investigated object surface. This is needs to realize diffusion lighting of object and to remove shadows on rough surface as powders. This specificity in lightning is differ that use in paper scanner or mobile phone cameras so it significantly improve measurement metrology. Color sensor is placed between LEDs under focus place of LED illumination so as to place at 45° to each LEDs and is armored by a black cylindrical shield. This prevents a penetration of direct and mirror reflected beams to sensor, only diffusion component is detected. The illuminant construction is important in investigation of objects with rough surface. Positioning sensor under investigated object at distance 10mm and presence relatively large input window of color sensor 1.2 ×1.2 mm do integration measurements from a spot Ø5 mm. This integrates a signal from surface and increases reproducibility and representation in real object measurements. Since real object frequently have microstructure of surface that need averaging between elements of structure on some representative square. Objects with 5 mm diameter as a minimal, easy-to-use, defensible size of investigated object.

Application of colorimeter as an analytical system places an intermediate state between naked eye measurement with color verification by printed sample

and spectroscopic measurements. Precision of colorimeter is comparable to spectrometer, so cheaper application of colorimeter is attractive for many practical tasks, though spectrometer stays universal instrument with more functional possibilities.

The testing of the developed colorimeter was done with indicator test system with different sorbents as polyurethane foam, silica and indicator paper. For all sorbents the colorimeter showed reproducible response. For analysis in selected range as (0.5–15)·μmol/l of Co^{2+} ions, (10–200) of Neutral Red indicator and (0.5–24)·mmol/l of Cu^{2+} reproducibility was not exceed 0,7%.

Colorimeter applications can be wider than operation with indicator test system. Flexibility of proposed device, small dimensions (70 × 60 × 35 mm), full USB compliance, low power consumption, peak power consumption does not exceed 0,5W (in a measurement mode) carry out analytical assays in different task include medical analyses or monitoring of ecological situation as laboratory as field test conditions. The colorimeter can resolve analytical task in other different fields as well as industrial application, control of technological processes where color information is an adequate characteristic.

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